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**Linear rolling bearing for transmitting torques**

The present invention relates to a linear rolling bearing for transmitting torques. Linear rolling bearings of this type are used in virtually all areas of mechanical engineering and motor vehicle technology. Parts which can be displaced longitudinally with respect to one another can be mounted with bearings of this type. In applications with shafts whose lengths can be adjusted telescopically, a bearing of this type has to additionally transmit the torques which are passed through the shaft. Shafts whose length can be adjusted telescopically are used, for example, as steering shafts of steering columns of modern motor vehicles. In steering columns of this type, the position of the steering wheel in the passenger compartment can be adapted to the individual size and posture of the operating person. In this way, the absolute spacing of the steering wheel with respect to the steering gear is changed. This change in spacing can be corrected by two shaft ends which are arranged inside one another so as to be displaceable telescopically.

For example, DE 199 33 875 A1 has disclosed a linear rolling bearing as claimed in the features of the precharacterizing clause of claim 1. The two profile elements can be displaced satisfactorily in the longitudinal direction with respect to one another. This is achieved by the rolling mounting, the rolling bodies circulating in endless circulatory channels. Torques of small magnitude can be transmitted between the two profile elements via the rolling bodies. However, if the prevailing torque exceeds a critical

value, the two profile elements rotate at least by a small rotational angle with respect to one another under resilient work, wall sections of both profile elements coming into contact with one another. The  
5 magnitude of the torque which is still transmitted via the rolling bodies can be defined by the design of the compressing elements. Above a critical torque, at any rate, the transmission takes place via the abovementioned contacts of the wall sections of the two  
10 profile elements with one another. In this known linear rolling bearing, the rolling bodies circulate in first and in second circulatory channels. Both circulatory channels have a loadbearing channel which is parallel to the longitudinal axis, torques or radial loads below  
15 the critical torque being transmitted between the two profile elements via the rolling bodies which are arranged in the loadbearing channel. Furthermore, said circulatory channels have a return channel which is parallel to the longitudinal axis and in which the  
20 rolling bodies return without load. The return channel and the loadbearing channel are connected to one another in an endless manner via deflection channels, with the result that the rolling bodies can circulate endlessly. The rolling bodies which are arranged in the  
25 loadbearing channel of the first circulatory channel can transmit torques in one rotational direction. The rolling bodies which are arranged in the loadbearing channel of the second circulatory channel can transmit torques in the opposite direction between the two  
30 profile elements.

Although the contact of the wall sections of the two profile elements with one another ensures that the rolling bodies of the two circulatory channels are not

exposed to any excessively high loadings as a result of overcritical torques, it is to be noted that a simultaneous relative displacement of the two profile elements with respect to one another in the longitudinal direction is possible above the critical torque only with friction work. This is because sliding friction is caused during the contact of the wall sections, a frictional force being a function of the prevailing torque.

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It is therefore an object of the present invention to specify a linear rolling bearing as claimed in the features of the precharacterizing clause of claim 1, in which a relative displacement of the two profile elements in the longitudinal direction is also possible without problems under torque loading.

According to the invention, this object is achieved by the fact that the first circulatory channel and the second circulatory channel can be connected to one another for jointly transmitting torques, the return channel of the circulatory channel which can be respectively connected being used as a loadbearing channel and the loadbearing channel of the circulatory channel which can be respectively connected being used as a return channel.

In the linear rolling bearing according to the invention, the sliding contact of the profile elements is absent at torques above a critical torque. Even torques above the critical torque are transmitted exclusively via the rolling bodies between the two profile elements. The contrivance of the invention is to be seen in the fact that, in both rotational

directions above the critical torque, the forces which occur are transmitted not only by the rolling bodies of the first or the second circulatory channel, but by the rolling bodies of the two circulatory channels. In  
5 other words, the invention can be described by the fact that, below a critical torque, substantially only the loadbearing channel of the first or of the second circulatory channel is provided for transmitting the torque, the return channel of the respective other  
10 circulatory channel being provided additionally above the critical torque as a loadbearing channel for transmitting this torque, and the loadbearing channel of said other circulatory channel being provided as a return channel. Therefore, only a reversal of the  
15 loadbearing channel and the return channel takes place in the connected circulatory channel.

The first or second circulatory channel can be connected to the respective other circulatory channel  
20 in different ways. In one variant which is preferred in accordance with the invention, a rotational angle (even if it is small) of the two profile elements with respect to one another about the longitudinal axis is a function of the prevailing torque, a critical  
25 rotational angle being exceeded above the critical torque, at which critical rotational angle the return channel is used as a loadbearing channel and the loadbearing channel is used as a return channel in the circulatory channel which is connected. Accordingly,  
30 below this rotational angle, the conditions in the loadbearing channel and in the return channel of the connected circulatory channel change, as will be explained in the following text.

In a known way, the loadbearing channel and the return channel are delimited in each case by an outer raceway for the rolling bodies, which outer raceway is assigned to the outer profile element, and by an inner raceway for the rolling bodies, which inner raceway is assigned to the inner profile element. The same is also true for the deflection channels of the two profile elements which are delimited in each case by an outer deflection track which is assigned to the outer profile element and by an inner deflection track which is assigned to the inner profile element.

Likewise in a known manner, the rolling bodies are arranged without play in the loadbearing channel, in roller contact with the raceways which delimit the loadbearing channel. It is ensured in this way that there is no rotational play between the two profile elements. Furthermore, the rolling bodies are arranged in the return channel with play with respect to the raceways which delimit the return channel. This is necessary, in order that the balls can be returned as far as possible without friction, in order to be deflected into the loadbearing channel again.

According to the invention, the play of the rolling bodies in the return channel of the circulatory channel which can be connected is reduced during the rotation (even if it is small) of the two profile elements with respect to one another. Furthermore, the play of the rolling bodies, with respect to the raceways, in the loadbearing channel of the circulatory channel which can be connected is increased during the rotation. This influencing of the play of the rolling bodies in the return channel and in the loadbearing channel is

possible in arrangements with a first and with a second circulatory channel, the first circulatory channel being provided for transmitting torques in one rotational direction, and the other circulatory channel  
5 being provided for transmitting torques in the opposite rotational direction.

In a linear rolling bearing according to the invention which is preferred from a technical and economic  
10 viewpoint, the outer profile element can have a hollow body and the inner profile element can have a shaft, a plurality of segments which are distributed over the circumference and delimit the circulatory channels together with the shaft being provided between the  
15 hollow body and the shaft. Every segment can be provided with the two raceways which are arranged parallel to one another, and with two deflection tracks which connect said raceways to one another. Segments of this type can be manufactured, for example, as a  
20 punched part cheaply. As a result of the provision of a plurality of segments, even small relative movements of the segments in the circumferential direction with respect to one another can be made possible, in order to avoid stressing between the two profile elements  
25 within the permissible tolerances.

The hollow body can be, for example, a tube, or else a sleeve or a ring.

30 Every segment can be supported on the hollow body in order to transmit a torque. For this purpose, the outer raceway can be configured as a ball groove on that side of the segment which faces the shaft, a convex shaped-out molding of the segment being formed on its side

which faces the hollow body. Said convex shaped-out molding of the segment can bear against a rest of the hollow body in order to transmit a torque. If the segment is manufactured from a metal plate with an identical wall thickness, that side of the metal sheet which faces the shaft can be provided with the ball groove which corresponds to a concave recess, the abovementioned convex shaped-out molding being produced by this pressing in of the recess on that side of the segment which faces the hollow-cylindrical body.

The hollow body can be provided with a plurality of shaped recesses which are distributed over the circumference, project radially inwardly and form the rests for the segments in order to transmit a torque.

The shaft is preferably provided with a plurality of teeth which are distributed over the circumference, are arranged parallel to the longitudinal axis and on which the raceways are formed. The raceways are preferably formed as ball grooves.

Teeth which are adjacent to one another delimit in each case a convexly curved circumferential section between them. This circumferential section which is as a rule partially cylindrical can delimit the deflection channel as a deflection track for the rolling bodies.

According to the invention, the hollow body can be deformed resiliently in a particularly advantageous manner. This property makes it possible in a simple manner to rotate the two profile elements with respect to one another, a resilient deformation of the hollow body being associated with this rotation. If the torque

is removed again, the hollow body is deformed back again, with the result that the initial position is reached again.

5 Another possible way of implementing the invention can provide, for example, spring elements which are arranged between the segments and the hollow body, the segments being supported in the circumferential direction by the hollow body via the spring elements.

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In the following text, the invention will be explained in greater detail using an exemplary embodiment which is illustrated in a total of two figures, in which:

15 figure 1 shows a cross section through a linear rolling bearing according to the invention, and

figure 2 shows the linear rolling bearing according to the invention from figure 1, in an exploded illustration in perspective.

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The linear rolling bearing according to the invention which is illustrated in figures 1 and 2 has an outer profile element 1 and an inner profile element 2. Rolling bodies 3 which are preferably configured as balls 4 are arranged between the two profile elements 1, 2. The balls 4 circulate endlessly in two first circulatory channels 5 and in two second circulatory channels 6, the two first circulatory channels 5 and the two second circulatory channels 6 lying diametrically opposite one another. The first circulatory channel 5 comprises a loadbearing channel 7 which is arranged parallel to the longitudinal axis of

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the linear rolling bearing, a return channel 8 which is likewise arranged parallel to the longitudinal axis of the linear rolling bearing, and two deflection channels 9 which connect the loadbearing channel 7 to the return channel 8 in an endless manner and which can be seen clearly in figure 2.

The second circulatory channel 6 comprises a loadbearing channel 10 which is arranged parallel to the longitudinal axis, a return channel 11 which is arranged parallel to the longitudinal axis, and two deflection channels 12 which connect the loadbearing channel 10 and the return channel 11 to one another in an endless manner.

The outer profile element 1 is composed of a hollow body 13 which is configured as a tube 14 in the present case, and further of four segments 15, 16 which are distributed over the circumference, two segments 15 being assigned to the first circulatory channel 5 and two segments 16 being assigned to the second circulatory channel 6. It can be gathered clearly from figure 2 that the segments 15, 16 are each provided with an endless ball track for the balls 4. On their sides which face the inner profile element 2, the segments 15 are provided with raceways 17, 18 which are configured as ball grooves 19, 20 in the present case. The ball grooves 19 delimit the return channel 8, and the ball grooves 20 delimit the loadbearing channel 7. In a corresponding manner, the segments 16 are provided, on their sides which face the inner profile element 2, with raceways 21, 22 which are configured as ball grooves 23, 24 in the present case. The ball grooves 23 delimit the return channel 11 of the second

circulatory channel 6, and the ball grooves 24 delimit the loadbearing channel 7 of the second circulatory channel 6.

5 In each case one cap 25 which is provided as a captive securing means for the balls 4 is arranged between the loadbearing channel 7 and the return channel 8 of every circulatory channel 5, 6. If the outer profile element 1 is pulled off from the inner profile element 2, the  
10 balls 4 cannot fall out inwardly from the outer profile element 1, as the caps 25 catch the balls 4 underneath. In normal operation of the linear rolling bearing according to the invention, the caps 25 are not necessarily required, and could also be removed.

15 Every segment 15, 16 has an annularly closed endless pressed-in portion, as can be seen in the perspective illustration of figure 2 on the outer side of the segments 15, 16. Said pressed-in portions form the  
20 above-described ball grooves 19, 20, 23, 24 on the sides which face the inner profile element 2. The segments 15, 16 have approximately the same wall thickness over their entire extent. Accordingly, convex shaped-out moldings 26, 27 correspond to the pressed-in  
25 portions on the inner side of the segments 15, 16, the shaped-out moldings 26 being formed on the segments 15 and, from them, the shaped-out moldings 27 being formed on the segments 16.

30 The tube 14 is provided with a plurality of shaped recesses 28 which are distributed over the circumference and project radially inwardly, in each case one of said shaped recesses 28 being arranged between two shaped-out moldings 26, 27 of two segments

15, 16 which are arranged next to one another. It can be seen clearly from figure 1 that the shaped-out moldings 26, 27 are supported on the shaped recesses 28 in the circumferential direction.

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It can be seen clearly from figure 2 that deflection tracks 29 are formed on the segments 15, as a result of the abovementioned pressed-in portions, and deflection tracks 30 are formed on the segments 16 for the balls 4, the deflection tracks 29, 30 connecting the ball grooves 19, 20, 23, 24 of the respective segments 15, 16 to one another in an endless manner.

In the present case, the inner profile element 2 is formed by a shaft 31. Said shaft 31 has four teeth 32 which are distributed over the circumference and project radially outward out of the cylindrical face of the shaft 31, every tooth 32 being arranged parallel to the longitudinal axis and being formed along the shaft 31. In each case one tooth 32 engages between two first and second circulatory channels 5, 6 which are arranged next to one another. It can be seen clearly from figure 1 that, starting from the top and rotating in the clockwise direction, the first tooth 32 engages between two return channels 8, 11 of the first and the second circulatory channel 5, 6, that the next tooth 32 engages between two loadbearing channels 7, 10 of the first and the second circulatory channel 5, 6, that the next (i.e. lowermost) tooth 32 engages between two return channels 8, 11, and that the last tooth 32 engages between two loadbearing channels 7, 10 again.

In each case one ball groove 33, 34 is formed on both longitudinal sides of every tooth 32, the ball groove

33 being assigned to the second circulatory channel 6 and the ball groove 34 being assigned to the first circulatory channel 5. The ball grooves 33, 34 delimit in each case the return channels 8, 11 or the loadbearing channels 7, 10.

Two teeth 32 which are arranged next to one another delimit in each case one cylindrical circumferential section 35 of the shaft 31. Said cylindrical circumferential section 35 delimits the deflection channel 9, 12. The balls 4 roll along said cylindrical circumferential section 35, in order to pass from the return channel 8, 11 into the loadbearing channel 7, 10.

The balls 4 are arranged without play in the loadbearing channels 7, 10. This means that there is no play in the rotational directions between the outer profile element 1 and the inner profile element 2.

The tube 14 of the outer profile element 1 is configured and dimensioned in such a way that it can be deformed under the action of a prevailing torque.

In the following text, the method of operation of the linear rolling bearing according to the invention will be explained in greater detail using figure 1. Initially, it is to be assumed that there is no torque, that is to say no torque is being transmitted between the two profile elements 1, 2. The outer profile element 1 is displaced longitudinally with respect to the inner profile element 2 as the balls 4 roll on the ball grooves 20, 24, 33, 34 of the loadbearing channels 7, 10. It can be seen from figure 1 that the play S is

formed in the return channels 8, 11, that is to say the balls 4 can return satisfactorily. If then, for example, a torque is introduced into the shaft 31 in the clockwise direction, this torque is transmitted by the balls 4 which are arranged in the loadbearing channels 7 of the first circulatory channels 5. In the illustration according to figure 1, these are the balls 4 of the first and third quadrants. If a torque is introduced into the shaft 31 in the counterclockwise direction, this torque is transmitted by the balls 4 which are arranged in the loadbearing channels 10 of the second circulatory channels 6. In the illustration according to figure 1, these are the balls 4 of the second and fourth quadrants. As long as the magnitude of the torques remains considerably below a critical value, the situation remains largely as shown in figure 1. This means that the play S is formed in the return channels 8, 11 as before.

If a torque above a critical magnitude is then introduced into the shaft 31 in the clockwise direction, although the forces which are produced are introduced into the tube 14 from the shaft 31 via the balls 4 as before, the magnitude of the forces which occur in the contact of the convex shaped-out moldings 26 of the segments 15 with the shaped recesses 28 of the tube 14 is so great that the tube 14 yields elastically outward under this force. In the further course, accordingly, a relative rotation (even if it is small) of the shaft 31 with respect to the tube 14 takes place in the clockwise direction. As a consequence of this relative rotation, the play S in the return channels 11 of the second circulatory channels 6 is reduced, in the second and fourth

quadrants. At the same time, a play is produced for the balls 4 in the loadbearing channels 10 of the second circulatory channel 6. In figure 1, these are the balls 4 in the loadbearing channels 10 in the second and fourth quadrants. Finally, the play S is canceled in the return channel 11 of the second circulatory channel 6, and the balls 4 are clamped under load between the ball grooves 34 of the shaft 31 on one side and the ball grooves 23 of the segments 16 on the other side.

10 In this situation, the torque is accordingly transmitted by the balls 4 of all the circulatory channels 5, 6. Accordingly, above the critical torque, the arrangement of the return channel 8, 11 and of the loadbearing channel 7, 10 is reversed in the second

15 circulatory channel 6 which has been connected. This reversal occurs during rotation of the two profile elements 1, 2 with respect to one another, a play originally formed in the return channels 8, 11 being canceled and, in contrast, a play being produced in the

20 loadbearing channels 7, 10.

It goes without saying that, in a corresponding way, torques above a critical magnitude can be introduced into the shaft 31 in the counterclockwise direction, a

25 corresponding reversal of the loadbearing channels and return channels of the circulatory channels which are connected taking place.

**List of reference numerals**

- 1 Outer profile element
- 2 Inner profile element
- 3 Rolling body
- 4 Balls
- 5 First circulatory channel
- 6 Second circulatory channel
- 7 Loadbearing channel
- 8 Return channel
- 9 Deflection channel
- 10 Loadbearing channel
- 11 Return channel
- 12 Deflection channel
- 13 Hollow body
- 14 Tube
- 15 Segment
- 16 Segment
- 17 Raceway
- 18 Raceway
- 19 Ball groove
- 20 Ball groove
- 21 Raceway
- 22 Raceway
- 23 Ball groove
- 24 Ball groove
- 25 Cap
- 26 Shaped-out molding
- 27 Shaped-out molding
- 28 Shaped recess
- 29 Deflection track
- 30 Deflection track
- 31 Shaft
- 32 Tooth

- 33 Ball groove
- 34 Ball groove
- 35 Cylindrical circumferential section